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The Sternal IO and Vascular Access-Any Port in a Storm

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Attempting vascular access by out-of-hospital medical providers is one of the most common and important interventions performed. Hypovolemia, hypothermia, obesity, previous intravenous drug administration or abuse, burns, and amputations complicate the establishment of venous access. Failure rates have ranged between 10% and 40%[1] and have taken upward and beyond 25 minutes to establish.[2] Such delays deprive a patient of intravenous fluids, volume replacement, and medications and delay arrival at definitive care. Delay in intravenous access and preceding interventions are associated with higher morbidity and mortality rates.[3] Establishing vascular access in 90 seconds, although widely considered an operational goal of out-of-hospital providers, is rarely achieved.

These concerns raise a fundamental issue with regard to patient care and treatment: is it in the best interest of the patient to "load and go," performing interventions in the air or ground unit under more difficult conditions, or should secure vascular access be a must-have priority before initiating transport?

The FAST 1 intraosseous (IO) device has been recently described in the air medical literature.[4] This new adjunct for achieving vascular access has proven beneficial for the following reasons:

- Training is easy and takes a minimum of time. The skill can be practiced repeatedly until a level of proficiency has been achieved.
- Application of the device is quick, with average insertion times of 77 seconds.[2]
- A high level of success (74%-95%) is achieved on first attempts.[2]
- Event-to-door time is reduced.
- Patient outcomes improve when treated faster.
- A high level of safety is provided for both the user and the patient.
- Situations for which the device is "not recommended" are minimal.

Inova AirCare added the FAST 1 sternal IO to the cache of equipment carried by flight crews. Our program is hospital based, and each flight crew consists of a flight nurse and flight paramedic. We perform approximately 40% scene and 60% interfacility transports. Flight nurse and paramedic training in IO was based on the manufacturer's training outline, video manual, and insertion simulator. We demonstrated full compliance and validated flight personnel skills before adding the device. Existing medical protocols were revised to reflect inclusion of the device as an adjunct for establishing parenteral access.

Within 30 days of adding the IO to our program, the device was used in an extraordinary clinical situation that was "not recommended" by the manufacturer. The flight crew decided to place the sternal IO after all other options for obtaining vascular access had been exhausted. Availability of the sternal IO was essential to the ability of prehospital care providers to deliver emergent care.

Flight Scenario

The patient was a 24-year-old man who had incurred 50%-60% third-degree burns to his abdomen, back, neck, arms, and hands. The patient had driven himself to a nearby residence for assistance, and the 9-1-1 system was activated. The patient had poor recall of what had happened, but it was suspected the patient had been fueling a hot equipment item (ie, chainsaw or tractor). When the flight crew arrived, the initial EMS responders had removed the patient's clothing and placed him in dry sheets. They increased the medical cabin temperature of their ambulance to aid in the patient's thermoregulation and administered high-flow oxygen by nonrebreather mask. Their attempts at peripheral IV access and fluid administration were unsuccessful.

The flight crew found the patient awake but confused and agitated. His airway initially was intact, but the flight crew remained very concerned about the probability of inhalation injury. Further attempts to achieve IV access in the patient's arms, neck, and lower extremities were unsuccessful (1-18ga angiocatheter was placed in a hand, but it became infiltrated after fluid instillation). The crew strongly considered to placing a sternal IO at this time, but this option was

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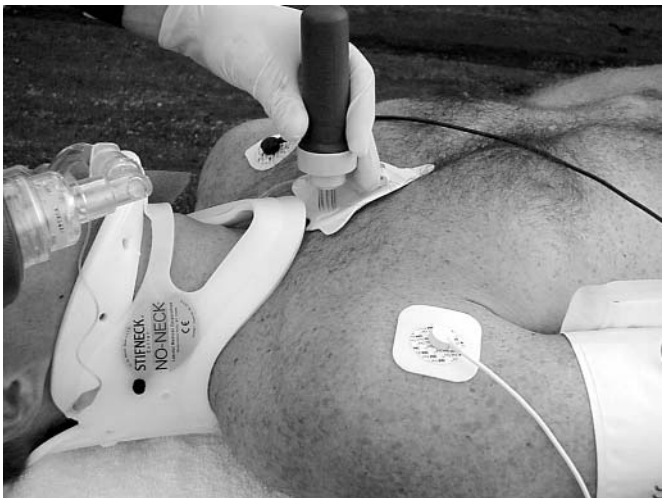
FAST 1 Intraosseous Device Materials



Proper placement of the IO device

deferred because of the manufacturer's "not recommended" guidelines in situations of impaired skin integrity.[5]

Given the patient's extraordinary circumstances, the flight nurse placed a 14-gauge, 3-inch angiocatheter in the femoral vein on the first attempt and initiated fluid administration. Our flight program does not routinely use central venous access as a part of medical provision. However, under exceptional situations in which the patient's condition is considered so critical that life or limb are immediately endangered, such contingencies may be attempted.

Along with 0.9% normal saline infusing at a rapid rate to gravity, a first round of sedatives and paralytic medications (etomidate, vecuronium, and midazolam) were administered through the femoral line in preparation for intubation because the patient's airway became progressively compromised. The patient became relaxed, appearing as if the medications were achieving their desired effect.

While the patient was being manually ventilated with a bag-valve-mask, he suddenly sat up, became combative, and rendered the femoral line unsuitable for use. The crew presumed that the patient's vascular depletion as a result of his burn injuries may have altered the rate of drug delivery and absorption. Furthermore, because femoral access was performed with an angiocatheter, it is possible the administered drugs may have extravasated into the surrounding tissues.

With failed IV access, sedative and paralysis medications administered with only partial effect, and a semiconscious patient with a deteriorating airway, the next option was placement of an IO needle in the medial malleolus. This was performed, but it also failed. A second IO needle was placed in the other ankle, and a good infusion rate was achieved. At this time, the previously administered medications finally took effect; the patient was successfully intubated, packaged, and taken to the aircraft. The total scene time was approximately 55 minutes. Although extensive, what further complications might have occurred if the flight crew had quickly "scooped and ran"?

In flight, the second IO needle began to fail. Given the configuration of the Bell 412, the flight crew was unable to safely reach and attempt to manipulate the failing IO needle. They decided to use the sternal IO, which they placed easily and without complication. Placing the target patch also was simple and straightforward, although this was a night flight and added the additional difficulty of low-light conditions and shadows. With the configuration of 1 attendant at the patient's head, aligning the introducer on the target patch and applying pressure on the introducer for insertion was excellent.

The approximate time to place the sternal IO and begin fluid administration was less than 2 minutes. A good flow rate by gravity of approximately 75 mL/hr was achieved. Fentanyl and midazolam were given through the sternal IO line, and a quick physiologic response was observed.

The remainder of the flight was uneventful. The patient maintained cardiovascular stability and uncomplicated ventilatory management. He was delivered to the regional burn center, the receiving team was instructed on removal of the device, and the removal tool (which is supplied with the introducer, target patch, and protective dome) was secured to the IV line attached to the sternal IO.

Multiple follow-up phone calls were made regarding this patient. His burns were formally calculated at 54%. He was progressing as expected with his therapies, with future surgical debridements pending. He remained mechanically ventilated but responded appropriately to commands. At 3 weeks, there was no evidence of infection related to placing the sternal IO on "impaired skin." There were no reported difficulties with removal of the device.

Conclusion

This case demonstrates one of the most difficult challenges faced by providers in the out-of-hospital environment. Vascular access remains a fundamental intervention that can in-

fluence patient outcomes. In addition, safety is a paramount issue for both the patient and the provider. Definitive measures must be performed, but a certain degree of patient control must be achieved before the actual transport can commence. Given the prolonged scene time required for this patient and the reliance on an extraordinary intervention that fell outside the usual spectrum of care delivered under protocol, earlier use of the sternal IO may have expedited patient transport.

Further review and discussion on the use of such devices will enhance the decision-making ability of out-of-hospital providers for this mode under similar clinical circumstances.

The utility of the sternal IO as an adjunct to obtaining vascular access has been demonstrated. Operational protocols for its use should incorporate all manufacturer recommendations and address additional exceptional considerations for extraordinary situations, such as those reported in this case. Impaired skin integrity from thermal injury, severe lacerations, or pre-existing scarring should be reconsidered with respect to the indications for sternal IO access.

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EDITORIAL COMMENT

AJ Macnab, MD

When does deviation from treatment guidelines constitute innovation in the standard of care? On 1 level, the decision in the report by Vojtko and Hanfling to use a FAST 1 intraosseous access needle in a patient with extensive burns can be viewed as clear deviation from the manufacturer's guidelines for use of their device. However, in the case described, adequate vascular access could not be obtained by other means, and the patient's immediate condition was severely compromised as a result. Consequently the paramedics' decision to use the FAST 1 before transport was in the best interest of their patient and entirely logical. Furthermore, the clinical improvement achieved with volume replacement through the IO route, subsequent successful transport to medical care, and the patient's survival all support the validity of the decision.

Fortunately, in spite of the skin over the sternum being severely burned, there were no subsequent infectious complications at the insertion site, and staff at the receiving hospital were able to remove the FAST 1 needle without difficulty. Thus in this scenario, all the important outcomes were favorable. So on another level, "irregular" use of a FAST 1 device can be seen as innovation.

Primum non nocere (first do no harm) is a legitimate cornerstone in medical care. In consequence, most of the care provided in an EMS prehospital context is protocol driven, and medical oversight dialogue, where available, makes it possible to extend or modify the treatment guidelines in place. Because most protocols are carefully conceived and evidence-based where possible, a process that monitors the incidence and effect of protocol deviation is a valuable quality assurance measure.

Salerno,[1] in a series of 1246 ALS ambulance calls, found that 16% involved protocol deviations. Most of these deviations occurred without dialogue or the consent of medical control. Fifty-five percent of deviations were minor, 38% were serious, and 7% were very serious. However, 89.5% of these patients were unaffected by the deviations from protocols, 5% actually improved, and 5.5% suffered complications, most of which were minor. Quality assurance of this type is valuable and enables education to occur and contributes to improvement of treatment guidelines where weakness is evident in the existing protocols.[2]

In the air medical transport environment, some teams have defined protocols, but most have treatment guidelines with significant flexibility in decision-making. Consultation with a physician overseeing the call is usually implicit in their pattern of practice because most care provided constitutes delegated medical acts. Sometimes circumstances are such or a case sufficiently complex that thinking outside the box and being innovative are essential for a patient to be transported successfully.

Strictly speaking (ie, from the standpoint of a transport medical director), a physician should be consulted before deviation from a protocol or device guideline occurs in each individual case. Although such discussion affords important medical and medicolegal support, it also must be recognized that physician oversight itself may cause or contribute to protocol deviation and errors of judgment.[1] It is of

greater relevance that during many transports dialogue with a physician is not always feasible, and where the immediate well-being of an actual patient is in jeopardy, the price of innovation requires that we accept the element of risk associated with irregular decisions made independently by transport personnel.

Clearly, such acceptance in no way endorses cavalier behavior or careless disregard for existing protocols, manufacturer's guidelines regarding drugs and equipment, or specific directives obtained from medical oversight. For deviation to be innovative, it is essential that the welfare of the patient drives every decision and that each caregiver acts entirely in the patient's best interest. It is also necessary that all the circumstances surrounding the deviation are documented to limit liability[3] and important to ensure that what has occurred is shared fully in an educational context.

Hippocrates[4] could have been talking about air medical transport when he said, "For extreme illnesses, extreme treatments are most fitting." Certainly this applies to the case Vojtko and Hanfling report. However, it is important that we share with our peers the failures as well as the successes of cases involving irregular decisions. While it is possible that only a small percentage of protocol deviations are harmful,[1] there is insufficient evidence in the literature to be certain.

Consequently, whether we call it quality assurance, research, or the acquisition of data on which to base our practice, it is essential to learn the positive and negative lessons from what is done and what is not done. Then, if we are truly innovative, this process is followed by constructive change, as following George Washington's advice, "We weigh the pros and cons and reason prevails." In other words, thoughtful and hopefully evidence-based review leads to improved guidelines, protocols, medical oversight, and treatments that enhance the quality and comprehensiveness of the care we provide patients who require transport.

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